raise the question: Does Group II consist only of nonulcer cases? If so, the conclusion would be logical.

From my recent observations with Schindler at the Billings Hospital, Chicago, and from my own experiences with the new flexible gastroscope, I believe we shall be compelled to revise, for purposes of classification as well as treatment, our ideas of what constitutes functional gastric disease. I am quite convinced that there exists a large group of so-called functional gastro-intestinal cases which can be shown to have mucosal ulcerations, and/or a type of gastritis which can be proved only by direct visualization of the gastric mucosa. These cases should be classified at present in Group I for purposes of this experiment, and not in Group II. If Group II, as amended, would still show the same percentage increase in acid, then only might one logically conclude that cigarette smoking causes the same percentage increase in gastric acidity, in gastric functional, and in peptic ulcer cases.

The importance of the work of Lickint, and of Danielopoln Simici and Dimitrin, referred to by Doctor Rosenblum, should be emphasized. They showed that inhalation of tobacco smoke causes, in smokers, gastric hypermotility. The use of a control group of smokers with normal stomachs, in Doctor Rosenblum's experiments, might have correlated these findings as regards acidity. This same group could also have shown the comparative effect of tobacco smoking by normals as against smoking by ulcer patients. The question would then arise, if there is a difference, is it due to the gastric pathology present? If no difference could be shown between the two groups, could we say that the increased acidity is an essential nicotine effect, or an effect due to some other factor present in the smoking process? The recent observations of Mahlo, as described in *Deutsche Medicine Wochenschrift*, 62: 1216, 1936, would lead us to the belief that the increase in acidity in Doctor Rosenblum's cases is not due to the effect of nicotin on the gastric pathology present. Mahlo contends that nicotin is not absorbed by either acid or alkali gastric mucosa, and has no effect on the lining epithelium of the stomach. It is absorbed, he says, in other organs and exerts its effects in the stomach through the splanchnic nervous system.

One of the most interesting facts presented in this paper is that the administration of alcohol subsequent to the smoking period produced no further increase in concentration of acid. The knowledge of this fact by an ulcer patient who, having persisted in smoking, wishes also to return to alcoholic indulgence, could in itself lead to a very interesting discussion between patient and his medical adviser.

This paper presents many problems for further investigative work, and it is hoped that Doctor Rosenblum will continue his study.

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Harold Lincoln Thompson, M. D. (1930 Wilshire Boulevard, Los Angeles).—Doctor Rosenblum has ably presented a paper on a subject of importance to those interested in the physiology of the stomach and duodenum, and in peptic ulcer. I have been interested in problems of gastric secretion, with particular reference to the surgery of the stomach, for a number of years.

In an interpretation of the results of Doctor Rosenblum's study, one must recognize the three phases of gastric secretion, namely, cephalic (psychic), gastric, and intestinal. Doctor Rosenblum has stated that all patients in his test group were chronic cigarette smokers. Since gastric and intestinal phases of gastric secretion for all practical purposes were excluded by the conditions of this study, the observer has dealt only with the cephalic phase of secretion. The response which the author observed in his experiments was conditioned in all instances by an appetite for cigarette smoking. It would be interesting, therefore, to know the reaction in a similar group of nonsmokers as a further control on the author's observations.

I believe that in these experiments the other phases of gastric secretion are relatively unimportant, excepting in so far as the subject may have swallowed saliva or mucus, thereby slightly neutralizing the gastric content. I hope that the author will favor us with a subsequent report on the observations on similar groups of patients who are not chronic cigarette smokers.

PHYSICS: ITS APPLICATION TO ROENTGEN THERAPY*

By Robert E. Pugh, Jr.
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Discussion *by Kenneth S. Davis, M. D., Los Angeles; John D. Lawson, M. D., Sacramento; George Stevenson Sharp, M. D., Pasadena.*

The magnitude of roentgen therapy dosages is expressed in terms of the "r unit," which is merely a unit of quantity of radiation analogous to the "milligram" used for expressing the dosages of pharmaceuticals. It was originally defined in the interests of universal duplication by physicists rather than in terms of any physiological or biological reaction. Although its magnitude is arbitrary, its use in expressing relative quantities of radiation is not limited by this fact. Changing of the size of units expressing a certain quantity does not influence the magnitude of the quantity itself, if the number of units is changed to compensate for the change in size. For example, in the case of drugs; if the gram were the usual unit instead of the milligram, obviously the number of units required for a given quantity would be just 1/1000th the number required in terms of milligrams.

NEED OF A UNIVERSAL UNIT

It should also be pointed out that the magnitude of successful dosages, in terms of r units, were determined clinically by radiologists and clinicians, physicists having had no direct influence on the choice of such values. Roentgenologists have recognized the position of the physicist as advisor and aide in applying physical principles to these dosages, but other physicians need have no fear that the dosages themselves have been tampered with by nonmedically trained men. The same clinical or biological dosage could be expressed in any units without altering its biological effect; the important point is to choose the units so that they may be easily and universally duplicated. It appears to be desirable that the dosage be expressed in terms of a universally understood quantity, rather than in terms of some degree of biological reaction which is incapable of exact description and duplication.

DEFINITION OF THE R UNIT

The official definition of the r unit has been given in the literature many times, but for the purposes of this discussion such a formal definition may well be omitted, and attention rather directed to the fact that it is merely a unit of quantity of radiation, just as the milligram is a unit of weight of material. More universal understanding of this fact should lead to greater confidence in roentgen therapy, and less confusion in the concepts of dosage.

It so happens that the magnitude of the r unit which was chosen is such that, in the present state of the science of therapy, most dosages fall within the range of 50 to 5,000 r units. Because of the way in which it is defined, the r unit (or intensities

* Read before the Radiology Section of the California Medical Association at the sixty-sixth annual session, Del Monte, May 2-5, 1937.

in terms of r units) may be determined directly by means of the standard open-air ionization chamber. Thimble-type ionization chambers, especially useful for surface and depth measurements, may be calibrated by comparison with the standard air chamber and used as secondary standards.

FUNCTION OF THE X-RAY PHYSICIST

The function of the x-ray physicist should be properly to measure the x-ray output of the equipment in r units so that the dosages will be reported in identical units throughout the world. Clinical medicine is burdened with too many other variables by nature not to eliminate variation in units when it is possible. If the dosage is so measured, then variations in clinical response may be assigned solely to individual variation or different pathological conditions. Calibration of intensity is essentially the same sort of standardization as the United States Pharmacopeia standards of concentration in pharmaceuticals. It is evident, then, that the calibration of the output in r units is not, in itself, any guarantee of successful clinical therapy. The deciding factor must always be the skill of the therapist in applying the experimentally determined dosages to the particular pathological problem at hand.

CHECKS ON THE OUTPUT INTENSITY

It is necessary to measure the output at such intervals that the roentgenologist may be continually confident that his dosages are being delivered exactly as planned, and have not varied due to possible mechanical and equipment variability. Variations in output seem to be due principally to changing characteristics of the x-ray tube itself. Sometimes such changes occur, sometimes not, but periodic measurement in r units will detect such changes or verify the constancy of output.

The x-ray machine control settings for obtaining a given kilovoltage actually select the desired fraction of the supply-line voltage to apply to the primary of the x-ray transformer. Occasionally the line voltage may change or fluctuate, in which case, although the selected fraction remains the same (for the same control setting), the magnitude of that fraction of the line voltage will be different, resulting in different kilovoltage on the x-ray tube and different output intensity. To avoid this variable factor, the indication of the primary voltmeter or kilovoltmeter should be relied upon rather than the control setting values. If the line voltage varies, the controls should be changed so that the voltmeter reading is the same as before.

Needless to say, all the factors of the technique chosen must be exactly determined to avoid error; differences in filter and distance are especially to be avoided to eliminate serious mistakes in dosage. It is only by using accurate dosage that the effectiveness of different techniques may be evaluated and the state of the art advanced.

MECHANICS OF ROENTGEN RADIATION

The mechanics of roentgen radiation is essentially a branch of the science of physics, but the application to medical uses is, of course, a specialty of medicine. The physicist, however, may point out certain fundamental principles governing the action of the radiation to aid the physician in applying this tool to his particular purpose.

The radiation emitted by an x-ray tube is of the same character as radio waves, heat and light; the essential difference lies in the wavelength of the radiation. The degree of penetrability of x-rays through opaque material is a function of the wavelength, which, in turn, is a function of the voltage applied across the x-ray tube. In general, the higher the voltage the shorter the wavelength, and the more penetrating the radiation. However, the radiation emitted at a given voltage does not consist of a single wavelength, but rather of a mixture; the peak kilovoltage determines the shortest wavelength, or most penetrating, component of this mixture.

BODY ABSORPTION OF THE BEAM

The longer, less penetrating components of this beam will be absorbed by the first layers of material placed in their path. This first layer may consist of the superficial skin layer of the patient, or it may consist of a metallic filter placed in the beam near the tube. If the skin absorbs these long wavelength rays, then a visible physiological reaction will appear (after an interval of some days), with less total radiation than if metallic filters had removed them before reaching the patient. Such is the case for superficial skin therapy. If a filter is used, the shorter wavelength radiation passing through the filter will not be as readily absorbed by the skin, and a greater total quantity of this filtered radiation may be administered before (after a certain interval) a visible skin reaction will appear. This is the reason for the observed difference in the total dose in r units required to produce an erythema with various qualities of roentgen radiation.

The greater the filtration (up to a certain point) the more nearly will the mixed beam be reduced to a single wavelength (homogeneous radiation), and the more uniform the dosage throughout the depth of the tissues. Similarly, the higher the peak kilovoltage the shorter will be the homogeneous radiation emerging after this optimum filtration. It now becomes evident that it is the physical phenomenon of absorption, in one form or another, which determines the choice of technique for different types of therapy.

In general low voltage, unfiltered radiation is considered more suitable for skin therapy, and in this case the skin absorbs the long wavelength components. High voltages (200 kv.) or supervoltage (above 250 kv.) are usually used for the treatment of deeply situated lesions (deep therapy), and in this case metallic filters are used to eliminate the long wavelength components, thus sparing the skin to a certain extent.

When the beam of radiation is incident upon the tissues of the patient's body, a certain amount of the radiation which penetrates below the surface is scattered by the atoms composing the tissue. By repeated scattering, a part of this scattered radiation finds its way back out through the same skin area exposed to the incident beam from the x-ray tube. The total dosage to which this area of skin is subjected is then the sum of the incident radiation from the tube and the back-scattered radiation. The amount of scattered radiation is dependent upon the size of the area irradiated, as well as the quality of the radiation. For larger areas the backscatter is greater, and the exposure time required for a certain dosage will be less than for a small area, where the contribution of backscatter to the dose is negligible.

DEPTH DOSAGE

Depth dosage is the relative quantity of the radiation present at the surface which penetrates to a given depth in tissue. Usually the depth dose is expressed in the percentage of skin intensity, which reaches a depth of 10 centimeters, both the surface and depth measurements, in this case, including scatter. In general, the shorter the wavelength of the radiation, the greater the depth dose, although it is also dependent upon the size of the field irradiated.

The distance of the source of radiation from the skin surface is another important factor in determining the choice of therapy technique, because the depth dose is also a function of this variable. The greater the source to skin distance the greater the depth dose. The low depth dose associated with surface radium applicators is utilized to limit the radiation effects to the surface layer involved in a skin lesion. For deep therapy, a reasonably long target-skin distance seems desirable for attaining the maximum depth effect for a given skin tolerance.

BACKSCATTER NOTATIONS IN THERAPY REPORTS

Because the amount of scattered radiation measured on the surface varies with the type of instrument used, and the underlying architecture of the anatomical part being irradiated, it seems advisable to report dosage values as measured in air, without backscatter. In any case, it is extremely important to state plainly in therapy reports whether the dosage values do or do not include backscatter. It is evident that gross errors might result from confusion regarding this point, since the amount of backscatter often exceeds 30 per cent of the primary beam. The size of the field irradiated should always be stated, and the total dosage for each area should be specified. The period over which the series of treatments extended is also necessary for a complete description of the technique.

The quality of the radiation should be carefully reported, giving both the kilovoltage and the filter used; the filter data should include both added filter and the inherent filtration of the tube, casing and fittings. The best single value available at present for describing the quality of the mixed beam is the half-value layer of some specified material, usually copper. This is the thickness of the material necessary to reduce the intensity to half its original value. Another term, the effective wavelength, is often used, but, since it is usually determined from half-value layer measurements or the equivalent, it seems best to use the original data.

The phenomenon of scattering is also important from the standpoint of the protection of the operator. Even though the equipment is completely ray-proof as far as the primary beam is concerned, the operator is exposed to the radiation scattered from the patient's body, and must be shielded accordingly.

Since the depth dose percentage measured with low voltage radiation is relatively low, and much less than for high voltage roentgen rays, it is impossible, even by prolonged treatment, to obtain adequate irradiation of a deeply situated lesion. By trying to accomplish this end valuable time is lost, during which the course of the disease progresses until it may be too late for proper deep therapy to be of any help.

ACTUAL DOSAGE RECEIVED BY THE TUMOR

The important consideration for therapy is the actual dosage received by the tumor. This may be calculated from depth dose data by adding the radiation received at the locus of the lesion from all the portals of entry used. Multiple ports ("cross-firing") permit a higher tumor dose to be built up than would be possible with one field, due to the limitations of skin tolerance. A safe dose, however, may be given to several skin areas with the beam properly directed, so that the lesion at a depth receives the sum of the radiation from all the ports of entry.

It has been recommended by the Standardization Committee that the therapist maintain a day book for recording all changes in equipment, tubes, calibrations, and other pertinent data. It was also suggested that individual treatment records be initialed by both therapist and technician, as a check for legal purposes, on such factors as filter, target-skin distance and dose administered.

SUMMARY

1. The r unit is a unit of quantity of radiation; dosages in terms of r units have been clinically determined.

2. Calibration of intensities in r units permits exact duplication of successful dosages and a universal basis for comparison.

3. The long wavelength component of radiation is absorbed either by the patient's skin or by a metallic filter. In the latter case the skin is spared to a certain extent and a greater amount of radiation is delivered to a depth before a skin reaction is evoked.

4. Backscatter, varying with the size of the area, contributes to the skin dose, and must be taken into consideration.

5. Dosages should be reported in air, without backscatter, together with the size of the field and the target-skin distance. Quality should be specified by voltage, filter (including inherent filter), and half-value layer in copper.

6. Protection against scattered radiation is necessary for the operator.

7. Tumor dosage may be increased by using several portals of entry, and not exceeding the desired skin dose for any one area.

8. Certain records should be kept for legal protection.

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DISCUSSION

KENNETH S. DAVIS, M.D. (St. Vincent's Hospital, Los Angeles). — Careful consideration of Mr. Pugh's paper brings out the fact that everyone doing x-ray therapy, whether a radiologist or otherwise, should utilize the services of an x-ray physicist to properly calibrate the machine that is being used for therapy. The physicist should be expected to accurately measure the output of the x-ray machine in r units, so that the dosage reported will be in such terms as can be understood by anyone doing x-ray therapy. The physician doing such therapy should bear in mind that the *allowable* dosage of x-rays depends on a number of factors:

1. The kilovoltage used.
2. The kind and the amount of the filter.
3. The size of the treated area.
4. The distance from the target of the tube to the skin of the patient.

He should also realize that there is a variability in the output of an x-ray machine from day to day, and that changes of any part of the apparatus, especially the x-ray tube, will influence the output of x-rays by a matter of as much as 5 to 10 per cent, all other factors remaining the same. For these reasons the periodic calibration of the x-ray therapy machine is essential.

At this point the duties of the physicist cease and those of the physician begin, for the physician must translate this physical knowledge into terms of biologic reaction; *i. e.*, the response of the tumor cells, and the *normal tissue cells surrounding them,* to a given dosage of x-rays correctly measured in terms of r units. Each case presents itself as an individual problem to the x-ray therapist, both as to the methods of therapy employed and the biologic response. The location of the tumor, the type of tumor cell, and many other facts will influence the treatment technique used.

Mr. Pugh states that dosages should be measured and reported in air without taking into consideration the back-scatter. I disagree with him on this point, as I find so much variability in the intensity of the radiation in the differently sized portals that it would seem wise to make this a matter of record. The back-scatter in our laboratory is determined by the use of the victoreen ionization chamber half-buried in a paraffin block, each size of the portals used in our work being calibrated once a month.

However, the r per minute in air is also recorded on our treatment chart for purposes of comparison with the records in other x-ray therapy laboratories.

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JOHN D. LAWSON, M.D. (1306 California State Life Building, Sacramento).—Certainly, the association of the physical and biological facts pertaining to radiotherapy is essential.

Until the relatively recent perfection of physical mensuration of radiation energies, and the adaption of an international unit of measurement, dosage was discussed in indefinite terms of "erythema doses." The variation of an erythema dose between two radiologists might be 50 to 75 per cent. Hence, each radiotherapist was a law unto himself, and comparative studies could not be made.

The point made by the writer, that "there should be no confusion between the biological result and physical measurement," should be stressed. Certainly, the same dosage (in roentgens) of heavily filtered radiation will manifest itself differently from an unfiltered application.

So, too, the various factors of kilovoltage, rate of administration, location of portal, size of portal, and many other factors require the knowledge of biological application on the part of the radiotherapist.

The assistance of the physicist has been great to the radiologist, but his purely physical measurement cannot in any way displace the detailed biological knowledge of the physician who has learned from observation and study the application of these measurements in the treatment of pathological conditions.

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GEORGE STEVENSON SHARP, M. D. (605 Professional Building, Pasadena).—This excellent paper by Mr. Pugh should be studied by every physician who employs radiation in any of its various forms. The basic factors of x-ray and radium therapy have been clearly defined, and a detailed check of the factors, recorded habitually, will promote more scientific treatment.

Knowledge, experience and judgment of radium and x-ray therapy are assumed qualities of a therapist in this specialty. Knowledge of dosages is essential, but the radiologist must know his equipment as any artist must know his instrument. Complete information must be available on the output of his machine. He may obtain this instantly by one of the various dosimeters, or by consulting a physicist at least every two months in order that mechanical or equipment variables may be known.

Knowledge of the r-unit output of a machine is essential for the present-day procedures in radiation. By the multiple divided dosage technique and multiple portals, one may now deliver to a deep-seated growth more radiation than the skin over it will tolerate. There is a fair margin of safety, but not sufficient to permit these heavy dosages without accurate data on the r-unit output and the type of radiation.

The principle of tumor dosage, and lethal or cancercidal dosages, have concentrated thought on the radiation one delivers to the tumor rather than to the skin. Radiation dosages are known for certain types of neoplasms, according to size, depth and degree of invasion, and a therapist is expected to deliver that required amount without permanent damage to the surrounding tissues or the patient. The dosage may be delivered in part by x-radiation and the remainder by intracavitary or interstitial radium, but the summation of radiation by all procedures should be equivalent to the calculated or required amount for that particular growth.

Dosages for such growth destruction cannot always be given, and for such patients the treatment should be considered palliative and primarily symptomatic. Much relief of pain and obstructive symptoms in various parts of the body may be obtained by less severe and palliative measures without untoward radiation effects in the incurable cancer patient.

I agree with Mr. Pugh that the mechanics of roentgen radiation is essentially a branch of the science of physics, but the application to medical therapy is a specialty of medicine and the physician must have this data constantly available to obtain the maximum beneficial effect of irradiation procedures.

HUMAN RABIES IN CALIFORNIA*

WITH DISCUSSION OF DIFFERENTIAL MICROSCOPICAL ANATOMICAL DIAGNOSIS

By J. C. GEIGER, M.D.
AND
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DISCUSSION *by J. L. Pomeroy, M. D., Los Angeles; W. M. Dickie, M. D., San Francisco; Hyman I. Vener, M. D., Los Angeles.*

RABIES is a serious and expensive preventable disease, since the financial losses in cattle and sheep represent a not inconsiderable figure. When rabies appears in a new territory, a few scattered cases are usually followed by a sudden sharp increase in incidence of the disorder. Reaching the maximum rather quickly, the epidemic presents almost an equally sudden decreased incidence. The actual spread through the territory may be slow and steady, and is probably dependent on the number of infected dogs traveling out of the affected areas. In fact, the spread could be anticipated and prevented in contiguous neighborhoods, but the well-known and effective measures of control are gener-

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* Symposium on Rabies, Pasteur Society of Central California, March 3, 1938.